

January 23, 1902.

Sir WILLIAM HUGGINS, K.C.B., D.C.L., President, in the Chair.

Mr. Arthur John Evans, Captain Henry B. Jackson, and Professor Charles J. Martin were admitted into the Society.

A List of the Presents received was laid on the table, and thanks ordered for them.

The following Papers were read :—

- I. "Mathematical Contributions to the Theory of Evolution. XI.—On the Influence of Natural Selection on the Variability and Correlation of Organs." By Professor KARL PEARSON, F.R.S.
- II. "On the Correlation of Intellectual Ability with the Size and Shape of the Head. (Preliminary Notice.)" By Professor KARL PEARSON, F.R.S.
- III. "On the Mechanism of the so-called 'Peripheral Reflex Secretion' of the Pancreas. (Preliminary Communication.)" By Dr. W. M. BAYLISS and Dr. E. H. STARLING, F.R.S.
- IV. "A Short Description of the Culicidæ of India, with Descriptions of New Species of Anopheles." By F. V. THEOBALD. Communicated by Professor E. RAY LANKESTER, F.R.S.
- V. "The Affinity of Tmesipteris with the Sphenophyllales." By Professor A. P. W. THOMAS. Communicated by Professor HOWES, F.R.S.
- VI. "On the Excretory Organs of Amphioxus." By E. S. GOODRICH. Communicated by Professor E. RAY LANKESTER, F.R.S.

"Mathematical Contributions to the Theory of Evolution. XI.—On the Influence of Natural Selection on the Variability and Correlation of Organs." By KARL PEARSON, F.R.S., University College, London. Received December 20, 1901,—Read January 23, 1902.

(Abstract.)

The influence of directed—natural or artificial—selection on the characters of a race is one which it is fundamental for the purposes of evolution to appreciate quantitatively. I have already shown in an

earlier memoir of this series the effect of random selection, or what it is better to term random sampling, on the characters of a population. Isolation of a few individuals who form a random sample may produce very sensible modifications of race characters, but it is to directed selection that we must look for changes on the largest scale. The subject is a very broad and complex one—no less than the total effect upon a population containing individuals at all ages of a selective death-rate applied for a long period and a function not only of the organs of each individual, but of the relationship of these organs to each other, and of the stage of growth of the individual. In its complete form the problem presents very considerable difficulties; but if we confine our attention to one class of the population, namely, individuals in the same stage of growth, we are able to trace fairly well the effect upon such a class of selection, however complex may be the relation between the organic characters and the death-rate. Thus we can measure the death-rate which would convert one race into a second by a cataclysmal action on the mean standard deviations and correlations of p out of n possible organs in mature individuals. New complexities arise if the individuals are reproducing themselves during the process of selection, which is then assumed to be continuous and not sudden.

At this point a very definite distinction is reached, namely, that between directly and indirectly selected organs. It may be said that, although it is possible for the recruiting sergeant to select stature, and in so doing differentiate the arm-length of his troop from that of the general population, yet that in natural selection we are given only the modified organs, and so we cannot tell which of them have been directly and which indirectly selected. Both are changed; how discover which was the source of the change? The answer is: In the same manner as we could distinguish between two recruiting sergeants, one of whom selected his troop from the general population by stature, and the other by cubit; in either case the stature and cubit would be both modified, but the mathematical theory of regression would enable us to distinguish between the methods of operating of the two men, and even between them and one who selected by *both* stature and cubit at once. The mathematical theory as developed in this paper shows us that, although the whole complex of characters may have been changed, still, if direct selection have only occurred in p out of n possible cases, there will be certain of the partial regression coefficients which remain unmodified and which will theoretically enable us to distinguish among the whole group of differentiated organs, between those directly selected and those modified only because they happen to be correlated with the directly selected organs. Thus the distinction becomes one of singular importance, for though the selection of a few organs modifies the means, variabilities and correlations, possibly of the whole

complex of characters, certain functions of those quantities remain constant, and such constants ought to be discoverable, at any rate in theory, and should serve as the criterion of a common origin, when we deal with local races as having been subjected only to a selection *directly* differentiating a comparatively few characters.

In this memoir the analysis is confined to the case of normal frequency, but most of the chief results are true for all cases of regression. The effects of selection are illustrated in a very considerable variety of cases, especially the influence of selection on the coefficients of heredity is fairly fully dealt with. Tables are given for the simpler cases to enable the biologist at once to appreciate the influence of selection, not only on the size and variability of organs, but on their correlations.

If selection has changed a race from a condition A to a condition B, it becomes of much interest to determine the nature of the selective death-rate by which the process has been carried on, and it is found that this death-rate as represented in the surface of survival-rates enables us to distinguish two kinds of selection, termed in the memoir positive and negative selection. In the first case a race is modified, because the nearer its members are to having their organs with a certain system of values, the better fitted they are to survive; in the second case the nearer the individuals are to this system the less fitted they are to survive. There will usually be in this second case, not a single system, but an indefinite number of systems which would equally well fit individuals to survive; in the first case, on the other hand, there are an indefinite number of systems which equally unfit their owners for surviving. This distinction seems of considerable interest.

For example, to select from the French race a race in femur and humerus like the Aino, we should have to proceed by a positive selection; but to select from the Aino a race like the French, we should have to proceed by a negative selection. To get 1000 Aino we should have to select for these two organs alone out of some 6,000,000 Frenchmen, but to get 1000 Frenchmen from the Aino we must select from about a billion of the latter. Thus we are to some extent able to appreciate the stringency of the selection, which even lasting through long ages, and introducing continuous reproduction, would be needful to enable us to pass in the case of only two organs from one race to the other. Another point brought out by the surface of survival-rates is the fact that the fittest to survive are usually not the most frequent survivors.

It will be seen that the memoir opens up a novel field of investigation, but one so wide that the theory of it must be limited by close contact with what is needful for the purposes of evolution. We want measurements on the local races of animals to guide us; at present we

know scarcely in any one case, whether differentiation has taken place by *direct* selection of few or of many organs. When once such measurements are forthcoming we shall have firmer ground to go upon, and the processes of the present memoir seem to suggest how in the future we shall be able to link together quantitatively local races, and possibly at a more remote date obtain quantitative conceptions of the stages of evolutionary descent itself.

“On the Correlation of Intellectual Ability with the Size and Shape of the Head. (Preliminary Notice.)” Drawn up by KARL PEARSON, F.R.S., University College, London. Received January 8,—Read January 23, 1902.

(A New Year's Greeting to Francis Galton, 1902.)

(1.) The collection and reduction of the material on which this preliminary notice is based were due to co-operative labour. Our aim was to ascertain which, if any, physical characters are sensibly correlated with intellectual ability. With this end in view we obtained leave from the Cambridge Anthropometric Committee to freely use their valuable series of measurements on Cambridge undergraduates. Our object was to discover whether these measurements had any relationship to the character of the degrees afterwards obtained by the measured. In order to do this it was necessary to copy the names of the persons measured, and ascertain what was the nature of the degrees ultimately obtained by them. The work of copying the names and colleges of the measured was first undertaken by Miss Mildred E. Barwell, of Girton College, and on her leaving Cambridge was continued and completed by Miss M. Beeton, of the same college. Miss Beeton prepared cards giving the name, college, and chief physical measurements of upwards of a thousand Cambridge undergraduates. This work was very laborious, and considerably increased by the number of duplicates which had to be discarded.* The next stage was to get the subject, place, and character of the degree ultimately taken by the measured placed upon the cards. The labour of tracing each individual in the publications of the University would have been

* There seems to have been a desire on the part of some of the measured to test the accuracy of the measurer by repeating the process as often as possible, and subjecting him to various artifices. One senior wrangler was measured no less than five times! Considering that the measurer had not the means of a prison warden for controlling his subject, he appears to have managed fairly well. When the duplicates were hopelessly irreconcilable—generally in those characters depending upon the agency of the subject—they were all rejected. In other cases where the differences were slight, the first measurements were taken as representative, and the later cards thrown out.